THE ACTION OF AN IRRITANT.*

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WHEN an irritant is applied to the skin it acts upon the nerve endings and the blood-vessels of the part, it having also a general and local action. The local action dilates the blood-vessels of the part, whilst it causes the other arterioles throughout the system to contract. Besides the local irritation of the nerves of the part, there is a reflected action through the nerves and the central nervous system upon the efferent nerves presiding over the muscular movements, circulation, and respiration. When a drop of bisulphide of carbon, or, after the skin has been rendered hyperæsthetic, a bull-dog forceps is applied to the back of the neck of a pigeon, the bird will run forward, then backward, rotating his body to the side opposite to that receiving the irritant, after which a hypnotic condition is seen for a few minutes, when he rouses up upon the slightest noise. Dr. S. Weir Mitchell has produced similar results with rhigolene, and lately Brown-Séquard has noticed similar phenomena with chloroform and chloral. The phenomenon with bisulphide I have already described a few years back.[1] Lately I have been trying to find other agents which would act in a similar manner upon the pigeon. The agents experimented with were dry and moist heat, turpentine, bro-

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mide of ethylene, parabromtoluene, a very irritating substance to the eyes, volatile oil of mustard, chloroform, ether, and alcohol. Of these articles, bisulphide, turpentine, and bull-dog forceps were the only agents producing these phenomena in the pigeon. In some cases the opposite leg and wing were partially paralyzed with anæsthesia of them, whilst hyperæsthesia ensued on the side of application. Upon cats and rabbits the carbon applied to the skin of the back part of the neck produces the wildest movements, followed by a remarkable disposition to sleep, and considerable anæsthesia of the extremities. These phenomena ensue in the pigeon when the surface of the cerebrum is destroyed, proving that the movements of body can be produced by gray matter at the base of the brain. When the surface of the cerebrum is removed no primary forward progression ensues.

Action on the circulation.—These phenomena were studied by means of Ludwig's kyniographion. About the end of a minute after the application of the bisulphide to the neck, the pulse falls considerably, whilst the pressure almost immediately rises, and continues to rise for some time.

Section of the vagi abolishes the reduction of the pulse, but the arterial tension increases as before. When the endings of the trigeminus in the nose are irritated, the pulse rapidly decreases as well as the number of respirations, as has been shown by Kratschmer. Brown-Séquard believed this cardiac arrest to be due to a direct reflex action, whilst Prof. Rutherford held that it was due to an excess of carbonic anhydride in the blood irritating the cardio-inhibitory ganglia, this excess being caused by arrest of respiratory movement. When he kept up artificial respiration he stated that there was no slowing of the heart. In my experiments with the bisulphide to the nose, with or without woorari,

and artificial respiration carried on through a tracheal canula, the heart was arrested as usual, showing that it is a pure inhibitory reflex. This reflex may come into play in operations about the jaws, causing sudden death.

Anæsthetic vapors or chloroform may bring this reflex into play, especially if anæsthesia is not very complete. The irido-sensory reflex, in ordinary anæsthesia by chloroform, is active, as I have often seen, and it is fair to presume that the play of the other reflexes may be present in part.

Effect on respiration.—When bisulphide is applied to the skin of the neck, and the surface of the cerebrum destroyed, the respiratory movements immediately increase, become deeper. When the bisulphide is applied to the nose, then the respiration soon decreases, even when the vagi are divided, showing that the trigeminal irritation calls into activity centres inhibiting the respiratory centre, like the same irritation inhibiting the heart.

Action on nervous system.—The inquiry arises, how are nervous phenomena to be explained? The cause of the phenomena is not circulatory, as the heart soon returns to its normal beat, whilst the pressure continues high, and the nervous symptoms continue some time. There is not sufficient anæmia of the brain to cause the series of phenomena. Their origin is not respiratory, as the breathing becomes deep and more frequent, which, so far as my experience goes, would not cause these changes. It seems to me that the phenomena are purely due to an excitation of the nervous centres themselves, and especially the inhibitory centres. When the trigeminus is irritated the heart is inhibited as well as the respiratory centres. Further, I have shown that reflexes can be inhibited by ganglia located at the base of the thalamus and head of the crura cerebri, and that these centres inhibit the general reflexes of the body, aided by spinal inhibitory centres.

I have also shown that these centres have fibres which demonstrate in the medulla and pons. The anæsthesia of the opposite side is explained by sensory irritation being carried up the cord on the same side and calling the inhibitory centres of that side into activity,—those about the base of the thalamus and head of the crura cerebri, which by their crossed action prevent the ascent of impressions, in a great degree, to the sensory ganglia above. That they pass mainly up the same side is due to the fact that the impulses upward meet here with less mechanical resistance, it not being necessary to traverse the gray matter of the cord. Not only do irritations of the skin prevent the transmission of the pulses upward, but they weaken or partially paralyze the motor-nerves of the opposite side. Thus, if I apply in a rabbit bisulphide of carbon to one side of the body, and then kill the animal by opening the chest, and after death irritate the sciatics, it will be found that the opposite sciatic is very much reduced in irritability. Reflex palsy upon this theory would be "inhibited paralysis." The discovery that an irritation of one side of the body will produce a partial paralysis of the opposite side is worthy of the attention of the neurologist in the explanation of reflex disturbances. The rotation to the opposite side is explained by a disturbance of equilibrium between the exciting and inhibiting ganglia of the central nervous system, which results in a deviation to that side. The state of hypnotism is simply induced by a peripheral irritation which has called the inhibitory ganglia into activity and temporarily suspended the functions of the will. The substance of my theory about the nervous system is as follows: that the gray matter is divided into inhibitory and excito-motor material; that the inhibitory is mainly located about the base of the thalamus and the head of the crura cerebri; that they are reinforced by inhibitory centres

above and by spinal inhibitory centres below; that these ganglia have their special fibres, beginning to decussate in the pons and ending a little below the rib of the calamus, and then passing down the internal half of the middle third of the lateral columns of the spinal cord; that anæsthesia after hemisection of the spinal cord is due to an excitation of these ganglia, whilst hyperæsthesia is due to a removal, in part, of the influence of these ganglia; hyperæsthesia and anæsthesia may also be due to affections of the excito-motor ganglia; that some partial palsies are to be explained by reflex irritation of inhibitory ganglia. Whilst holding these ideas I believe in an excito-motor nervous system, that the motor nerves decussate, that the sensory also do, and that the cerebral excito-motor ganglia are also localized.

Effect on temperature.—When a pigeon is held loosely in the hand and the bisulphide applied to the skin of the neck, the rectal temperature falls.

The conclusions on the effect of irritants are as follows:

1. Certain irritants applied to the skin produce a variety of phenomena of the nervous system. Other irritants do not.

2. These phenomena are not due to circulatory changes as usually held, but to an excitation of the central nervous system.

3. Irritations of the skin diminish the irritability or partially palsy the motor nerves of the opposite side.

4. They also produce anæsthesia by a stimulation of inhibitory ganglia.

5. When applied to the nose they inhibit the heart and respiratory centres.

6. They excite the monarchical vaso-motor centre.

7. They lower the temperature.

8. They dilate the pupil.